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Zooplankton

R. Jyothibabu and N. V. Madhu

National Institute of Oceanography, Regional Centre, Kochi 682 018, India.

7.1 INTRODUCTION

Zooplankton, also known as secondary producers, are tiny floating or drifting animals of aquatic systems. While a few zooplankton are capable of independent movement vertically (a behaviour called vertical migration), their horizontal movement is primarily determined by water currents. These animals play an important role in aquatic systems as intermediate members of the food web. In this chapter, we review what is known about zooplankton in the Mandovi and Zuari estuaries. The next section examines the composition of zooplankton in the estuaries. Section 7.3 describes the annual cycle of zooplankton biomass and abundance. The last section examines a couple of issues that have remained unaddressed and need to be pursued in these two estuaries.

7.2 ZOOPLANKTON COMPOSITION

The Mandovi and Zuari estuaries comprise zooplankton fauna of nearly 20 different taxonomic groups. A list of major groups of zooplankton, based on a year-long study in the two estuaries, is given in table 7.1 (after Padmavati and Goswami 1996). Crustaceans in general, and copepods in particular, dominate the zooplankton community. Species belonging to the copepod families Acartidae, Pseudodiaptomidae, Paracalanidae, and Acrocalanidae are common in these estuaries

Table 71 Average numerical abundance (ind m^{-3}), unless noted otherwise, and percentage composition (in parenthesis) of major groups of zooplankton in the Mandovi and Zuari estuaries (from Padmavati and Goswami 1996).

Zooplankton groups	Mandovi	Zuari	Cumbarjua canal
Hydromedusa	2.5 (0.15)	1.2 (0.08)	2.3 (0.3)
Siphonophora	0.01 (0.0)	0.5 (0.03)	0.0 (0.0)
Ctenophora	0.1 (0.01)	1.4 (0.09)	0.1 (0.01)
Chaetognatha	10.6 (0.67)	21.1 (1.43)	28.3 (3.31)
Cladocera	4.1 (0.26)	10.4 (0.73)	0.3 (0.03)
Ostracoda	0.0 (0.0)	0.2 (0.01)	0.01 (0.0)
Copepoda	1354 (86.11)	1242 (84.35)	696 (81.39)
Amphipoda	0.2 (0.01)	0.1 (0.01)	0.2 (0.02)
Lucifers	33.3 (2.12)	43.4 (2.95)	13.5 (1.57)
Mysidacea	1.1 (0.06)	2.5 (0.16)	0.7 (0.08)
Cumacea	0.2 (0.01)	0.5 (0.03)	0.3 (0.03)
Invertebrate eggs	0.5 (0.03)	0.9 (0.06)	0.1 (0.01)
Invertebrate larvae	154.3 (9.81)	131.6 (8.93)	109.8 (12.83)
Pteropoda	0.0 (0.0)	0.1 (0.0)	0.0 (0.0)
Copelata	4.5 (0.29)	9.7 (0.65)	0.8 (0.09)
Fish eggs	4.0 (0.25)	4.7 (0.32)	0.04 (0.0)
Fish larvae	2.8 (0.19)	2.0 (0.13)	2.7 (0.31)
Miscellaneous	0.1 (0.01)	0.1 (0.01)	0.1 (0.01)

(Madhupratap 1987; Padmavati and Goswami 1996; Achuthankutty *et al.* 1997). About 49–55 species of copepods inhabit the estuaries (Goswami 1983; Achuthankutty *et al.* 1997). Other groups that are usually found in the zooplankton community are larvae of decapods and cirriped, sergestids, cladocerans, fish eggs, fish larvae, chaetognaths, copelates (appendiculareans), gastropod larvae, cumaceans, hydromedusae, and amphipods (see figure 7.1). Padmavati and Goswami (1996) have noted that the zooplankton composition does not differ appreciably between the Mandovi and the Zuari.

Since estuaries lie in the region of transition from marine to freshwater zones, they have a wide range in the distribution of salinity, which in turn forms a controlling factor in the distribution of zooplankton in Indian estuaries (Rao 1976a; Madhupratap 1987). Estuarine zooplankton from an estuary can be divided into three components:

- marine species restricted to the seaward part of the estuary, and hence adapted to the high-salinity range;

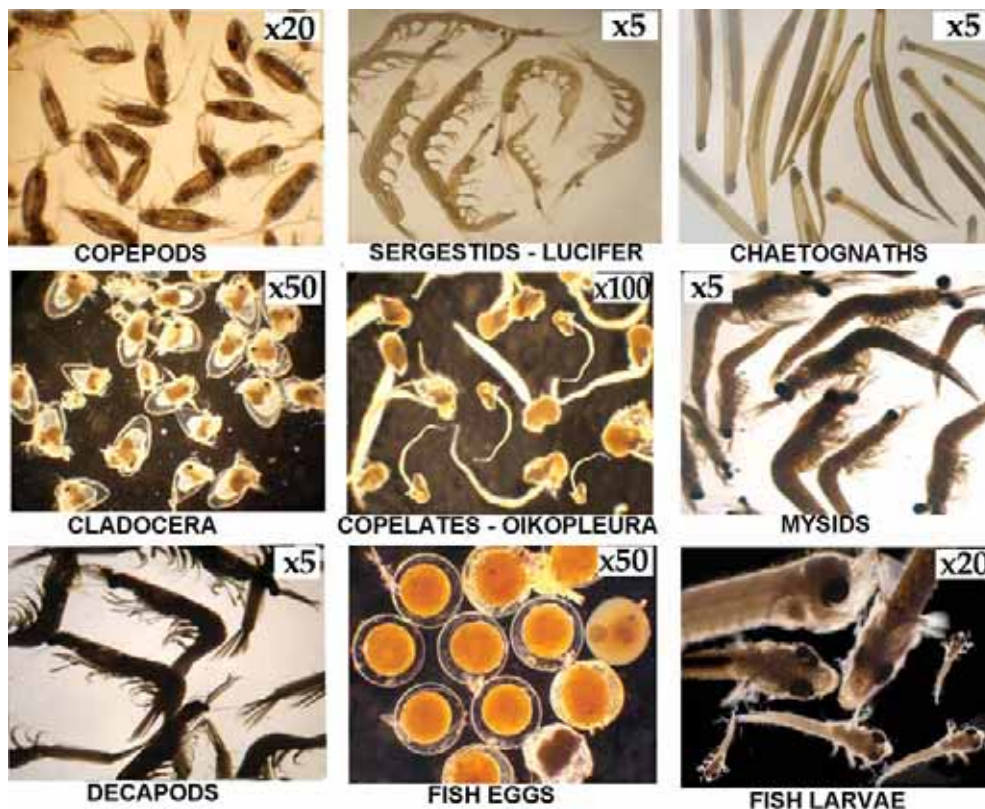


Figure 7.1 Major groups of zooplankton in the Mandovi and Zuari estuaries.

- organisms that live in brackish water; and
- fresh water species of the upper estuary (Miller 1983).

Achuthankutty *et al.* (1997) have determined that in the Mandovi and Zuari estuaries, 50% of the copepods live in the salinity range of 26–36 psu, 30% live in the intermediate salinity range of 5–36 psu, and 10% in the range 2–5 psu. Figure 7.2 provides a summary of prominent species of copepods in the two estuaries and the range of salinity in which they are found.

Goswami (1983) grouped copepods found in the two estuaries on the basis of their occurrence and abundance during different months of the year. He considered the following three groups: (a) species recorded either throughout the year or most of the years, (b) species recorded during certain months, and (c) species seen only occasionally. It was found that category (a) constituted 50–60% of the total copepods found in the estuaries. They were distributed in the entire stretch of both estuaries. The copepods of the category (b) were immigrants from the coastal waters and were abundant from February to May. The third category included mostly freshwater species occurring in water with salinity less than 0.5 psu.

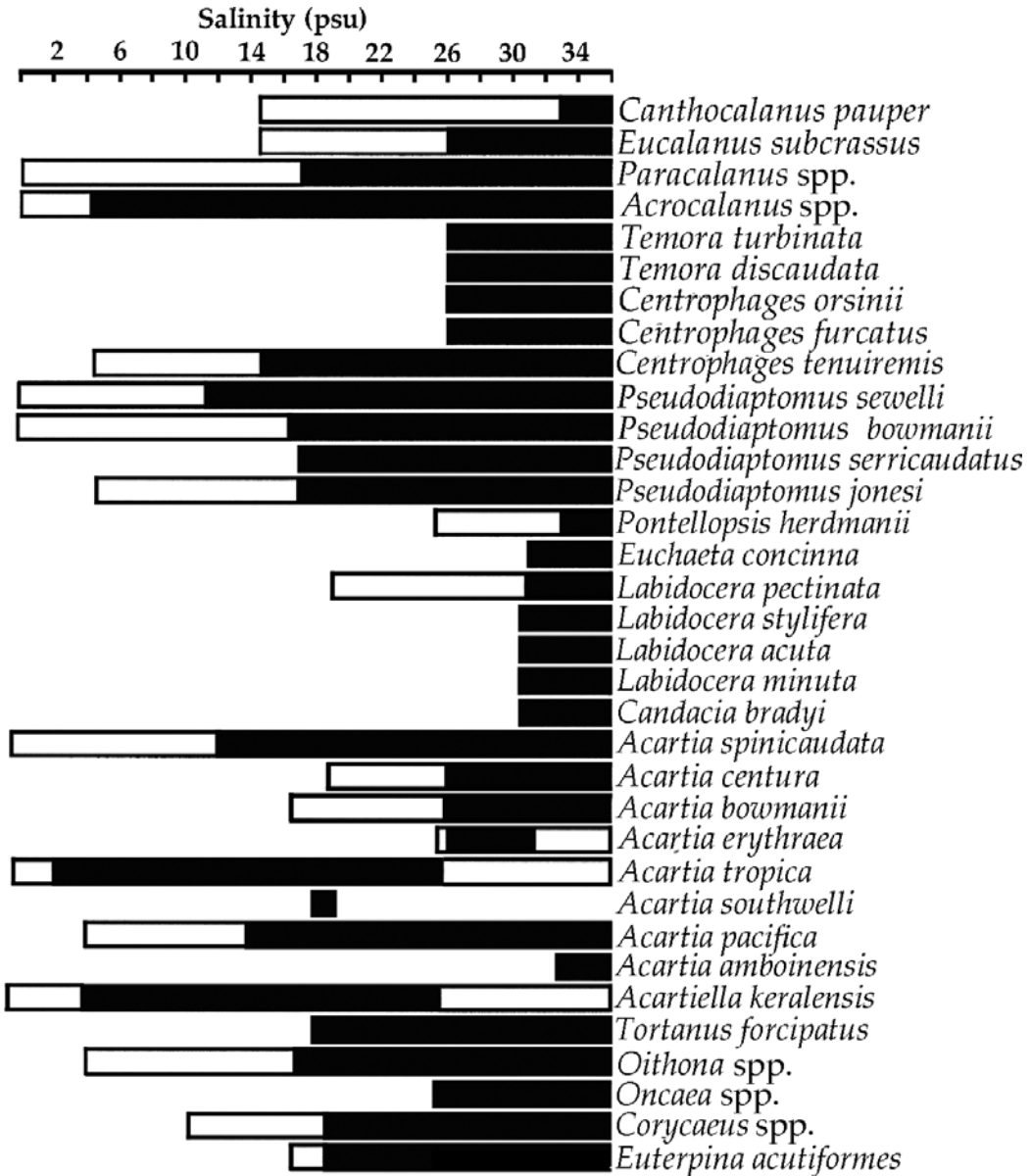


Figure 7.2 Salinity ranges and the occurrence of different copepod species in the Mandovi and Zuari estuaries. Dark areas indicate the ranges of greater abundance (from Achuthankutty *et al.* 1997).

Ecological succession is a slow process of change in the number of individuals belonging to a species of a community, or of the establishment of the new populations. In the latter case, the new species may gradually replace the original inhabitants. This process is widespread in marine plankton communities, and is

mainly associated with seasonal changes in hydrography. Succession of copepods in the Mandovi and Zuari estuaries begins after withdrawal of the monsoon by mid-October. At this time, the salinity in the estuaries begins to increase, particularly near its mouth, and coastal copepods invade (Goswami 1983). Subsequently, the specie diversity increases. It appears to peak at the end of the dry season, just before the summer monsoon sets in. With the onset of the monsoon begins the flushing of the estuaries by freshwater runoff and copepod biomass and diversity drop. The lowest diversity and biomass of zooplankton in the two estuaries is found during the high-runoff and low-salinity time of the summer monsoon.

7.3 SEASONAL VARIATION

Figure 7.3 provides an overview of the annual cycle of zooplankton biomass and abundance in the Mandovi and Zuari estuaries; the figure is based on the data reported in Padmavati and Goswami (1996). From the monthly data of seven locations (see figure 7.4 for locations), no clear seasonal cycle is apparent, but a consistent feature seen in both biomass and abundance is that they attain their lowest annual value during June–August. This is the time when the summer monsoon is active, runoff is high, and salinity is at its lowest during the year. Other than this one feature, that too a rather weak one, there is no distinguishing pattern to the variability. The low abundance and biomass during the monsoon could be a consequence of the following three processes.

- First, there is the physical mechanism of flushing of the estuary because of the large runoff that replaces the water in the estuary many times over during the rainy season. This effect is expected to be particularly high in the Mandovi, whose runoff is higher and volume lower than that of the Zuari.
- Second, salinity is low in the estuary at this time of the year. As noted earlier, 50% of the copepods live in the salinity range of 25–26 psu. Such salinities can be expected only near the mouth of the two estuaries in the region of the bays.
- The third factor is availability of food: phytoplankton concentration is at its lowest during the rainy season (see chapter 6).

Figure 7.3 shows that the average zooplankton biomass is significantly higher during the dry months of October–May than during June–August, but there is no pattern to the evolution towards the increased biomass of the dry season from the low values of the rainy season. A couple of stations in figure 7.3 show a sudden spurt in biomass during September, when the withdrawal of the monsoon begins; there are, however, other stations that do not show this feature. There is also no easily recognizable pattern to the evolution of biomass or of abundance during the entire eight-month-long dry season.

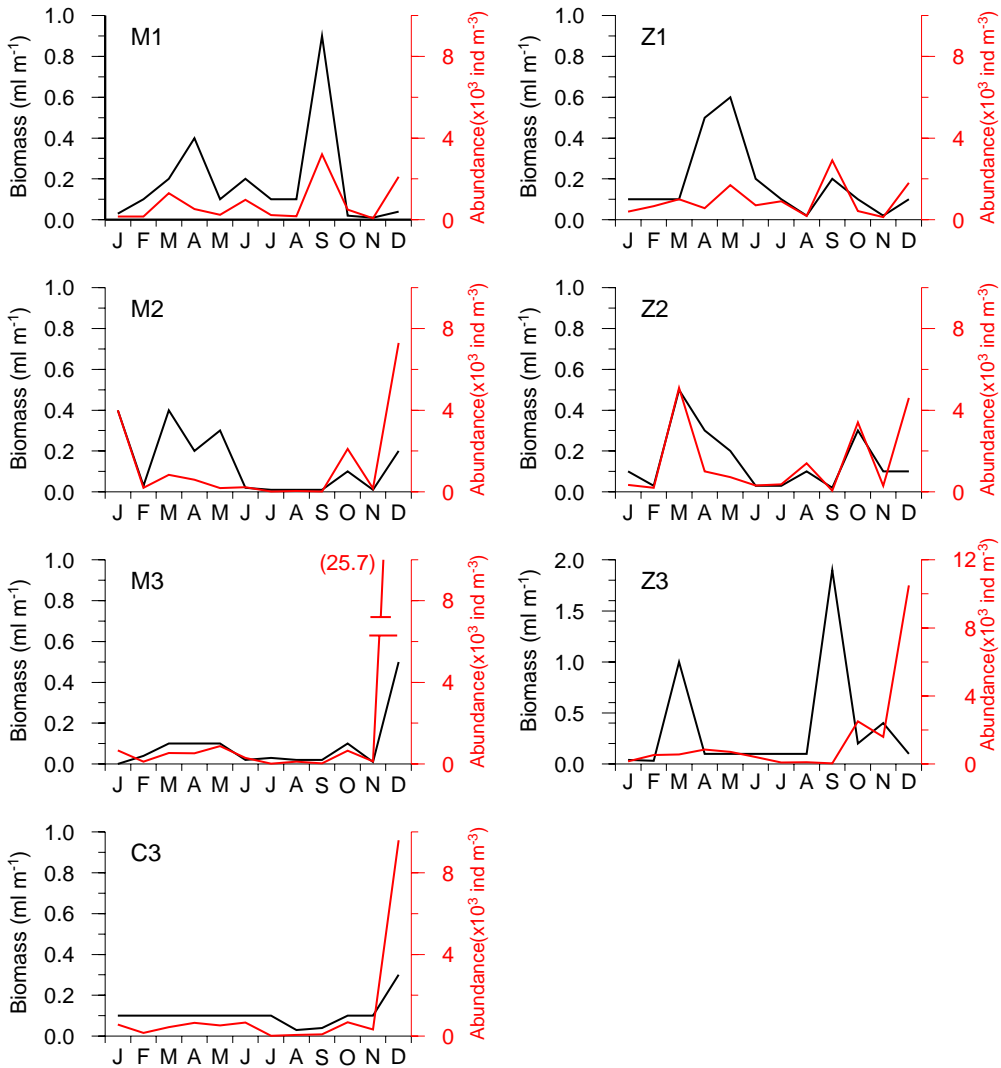


Figure 7.3 Zooplankton biomass (ml m^{-3}) and abundance (ind m^{-3}) at stations M_1 , M_2 , and M_3 in the Mandovi, Z_1 , Z_2 , and Z_3 in the Zuari, and at location C_1 in Cumbarjua canal. These locations are shown in figure 7.4. The data used in the figure above were collected during January–December 1990. Note the high value of abundance at station M_2 ; this one value was well beyond the range of the axis. Data source: Padmavati and Goswami (1996).

7.4 DISCUSSION

Zooplankton samples are usually collected using a plankton net with a mesh size of $200\mu\text{m}$. This mesh retains the so called mesozooplankton but excludes groups of species smaller than $200\mu\text{m}$ (microzooplankton) that comprise developmental stages of the mesozooplankton. These microzooplankton are capable of exploiting

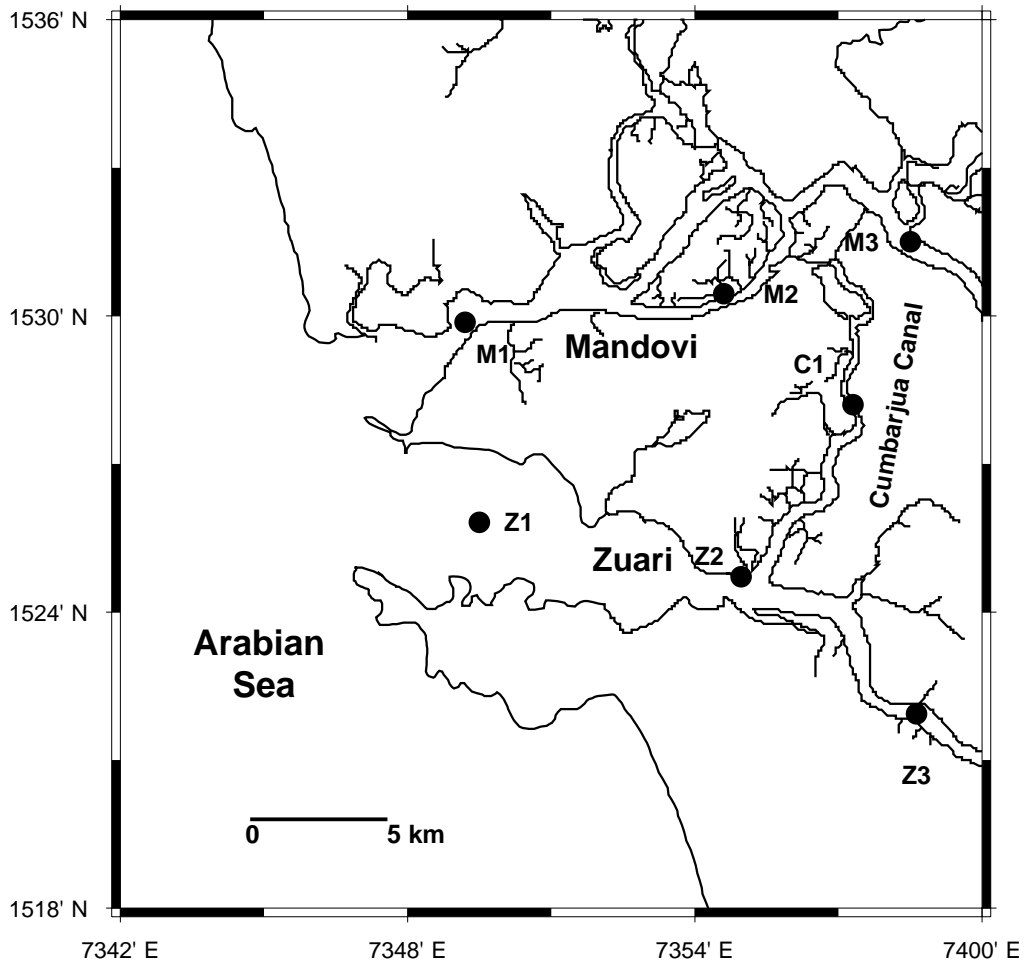


Figure 7.4 Location of stations from where data have been used in figure 7.3.

pico and nanoplankton that are inefficiently utilized by other, larger zooplankton. They also act as a significant food source for a variety of larger zooplankton and vertebrate predators (Robertson 1983; Stoecker and Capuzzo 1990), thereby acting as a trophic intermediate between pico/nanoplankton and mesozooplankton. The microzooplankton is known to be crucial for transfer of organic carbon from heterotrophic bacteria to higher trophic levels — the microbial loop (Azam *et al.* 1983). There are not many studies on microzooplankton from the Mandovi and Zuari estuaries. Available information, based on Gauns (2000), indicates the presence of a rich microzooplankton community in the Mandovi and Zuari estuaries. The community is qualitatively and quantitatively dominated by ciliated protozoans (e.g., tintinnids), with nearly 60 species recorded (figure 7.5). Their abundance is higher during the dry season (in excess of 30000 ind l^{-1}) than the wet season (less than 10000 ind l^{-1}). This perhaps indicates a key role for salinity in controlling the

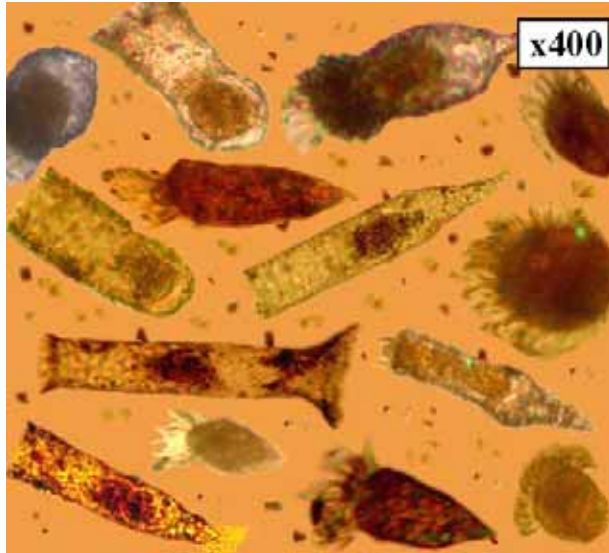


Figure 7.5 Common ciliates of microzooplankton, in part carrying lorica (house).

microzooplankton community (similar to that of larger zooplankton). On the other hand, this could mean that with high runoff, the production of microzooplankton within the estuary gets flushed out during the wet season. In recent years, a number of studies have highlighted the role played by microzooplankton in Indian estuaries (see, for example, Godhantaraman 1994; Jyothibabu *et al.* 2006; Madhu *et al.* 2007). There is a need to take up similar studies in the Mandovi and Zuari estuaries.

There is also a need to understand processes that control zooplankton abundance. This would require establishing a link between zooplankton and their predators in the Mandovi and Zuari estuaries. In summary, our understanding of zooplankton in the two estuaries remains inadequate at this stage. Critically needed are field experiments that can describe the zooplankton field, as well as the rates of growth and mortality, with more certainty than the present data are capable of doing.

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